ELIT
Economic Laboratory Transition
Research Podgorica

Montenegrin Journal of Economics

For citation:

Benyoussef, S., Jbir, R., Belkhir, N. (2026), "The Relative Efficiency of the Health Sector in Saudi Arabia: A Data Envelopment Analysis",
Montenegrin Journal of Economics, Vol. 22, No. 1 pp. 159-175.

The Relative Efficiency of the Health Sector in Saudi Arabia: A Data Envelopment Analysis

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ARTICLE INFO

Received September 23, 2024
Revised from October 02, 2024
Accepted November 08, 2024
Available online January 15, 2026

JEL classification: C00, C02, D61, H51, I13, I15

DOI: 10.14254/1800-5845/2025.21-1

Keywords:

Data envelopment analysis,
Efficiency,
Health care

ABSTRACT

This study evaluated the efficiency of primary health care centers and government hospitals in Saudi Arabia by measuring their productive efficiency via data envelopment analysis. Four inputs and three outputs from the primary health care database and four inputs and four outputs from the government hospital database were subjected to the analysis. The period examined spanned 2014 to 2019, and the data covered 20 regions. The constant returns to scale and variable returns to scale models showed that there were four (20%) and six (30%) regions with efficient primary health care centers, respectively. For government hospitals, however, the number of such regions was seven (35%) and 10 (50%), respectively. The findings confirmed that government hospitals are more efficient than primary health care centers. The inefficient regions could benefit from these findings to compare their system and performance considering the efficient regions within their capacity and geographic location.

INTRODUCTION

After almost three years of the COVID-19 crisis, all economic sectors, especially health, are confronted with new challenges. In this situation, these sectors need to adopt modern management concepts so that they can effectively and efficiently achieve their goals. Another necessary task is to reinvigorate methods of public administration and adopt new strategies given intense competition and global economic and political changes. Inputs from various sectors enhance the performance of government service agencies by stimulating environmental challenges and transformations and enabling the rationalization of spending, speedy implementation, and the simplification of procedures. These goals can be realized through a comprehensive approach to administrative development that involves the efficient use of resources and the constant improvement of service quality to increase customer satisfaction.

In this context, a seemingly important strategy is to regularly measure the institutional performance of organizations to verify the level of service quality provided by their administrative divisions. Among such organizations are health care institutions. Because of constant change, the health sector today faces major constraints in the allocation of resources to it. These resources should therefore be efficiently used for health care institutions to satisfy the changing and growing needs of their beneficiaries. The World Health Organization proved that there is an important waste in health system in the world (Asbu et al., (2020)). The optimal use of resources requires clear and accurate data on resource flows and their effects on the level of excellence and effectiveness of healthcare.

As with the health sector in many other countries, that in Saudi Arabia has been strongly developing for some time. This development is reflected in the country's health indicators for all aspects of prevention, treatment, maternity, and childcare. Despite this progress, however, the sector grapples with many challenges, particularly in terms of enhancing the efficiency of health services and providing necessary resources to the population. In consideration of this issue, this research evaluated the efficiency of primary health care centers and government hospitals in Saudi Arabia by measuring their productive efficiency. For this purpose, we conducted two types of analysis: statistical analysis and data envelopment analysis (DEA).

The rest of the paper is organized as follows: Section 2 presents a brief literature review, and Section 3 describes the evolution of health services in Saudi Arabia. Section 4 discusses the methodology and model used in this work. Section 5 concludes the paper.

1. LITERATURE REVIEW

To understand efficiency, we must first explain the concept of inefficiency. Economically, inefficiency means that any amount of input yields less than the maximum output that must be produced given the technology used (production function). If inefficiency occurs, then there is a problem in an input or a production system. This problem is corrected through the authority intervention in all cases. Asbu et al., (2020) consider that inefficiency is a great problem for health system in countries and authorities must measure periodically the efficiency of health sector. In a health care system, inefficiency can be explained by two factors. First, input (resources) is directed toward services that are not among the priorities of the system. Second, these resources are improperly used. In this study we use the Peter Drucker (1966) definition of efficiency. For them, efficiency is doing things in the most economical way (Burches and Burches (2020)). In the other meaning, we focus mainly on output to input ratio in health system.

There are many research (Hussey et al., (2009), Bem et al., (2014), Asanduluia et al., (2014)), Yip and Hafez (2015), Asbu et al., (2020), Farooq et al., (2021), Mbau et al., (2022), Lacko et al., (2023), Sicari and Sutherland (2023)) investigated the efficiency in health sector in the world.

Hussey et al., (2009) reviewed the methods used to measure the efficiency in health sector. They proved that the majority of used methods are DEA and SFA (stochastic frontier analysis) methods. However, other researchers used the Malmquist productivity index (MPI) to evaluate the efficiency in healthcare system (Lacko et al., (2023)). This index follows the change of productivity in healthcare system over time. One of the techniques employed to assess the effectiveness of the healthcare system, is the DEA method in the first rank following by SFA method in the second position (Mbau et al., (2022)).

To assess the effectiveness of healthcare systems in OECD nations, Bem et al., (2014) used two indicators which consider a socio-economic factor such as equity of access to health care, number of health care services and patients. They focused to explain the relation between these factors and health care expenditure and therefore measure the health care system efficiency. They conclude that given the socio-economic factors used in the study, the health system in OECD countries is overall effectiveness.

In 2010, the efficiency of healthcare systems in 30 European countries was evaluated using the DEA method by Asanduluia et al., (2014). Their findings showed that the healthcare systems in most European nations are not effective. In the contrast, the authors proved that health system of some developing countries like Romanian and Bulgaria was efficient. The same results were found by Medeiros and Schwierz, (2015) for other European countries (Belgium, Cyprus, Spain, France, Italy, Sweden and the Netherlands). Also, the Lacko et al., (2023) results confirm that the efficiency of health care system of Europeans countries is weakened especially the countries that joined the European union in 2004.

Yip and Hafez (2015) indicated that health care efficiency can be ensuring in addition to ministry of Health by the intervention of independent regulatory agency. These later can ensure the monitoring and evaluation of health system reform and have the autonomy of decision-making.

Using DEA method for 261 rural public health centers in Pakistan, Farooq et al., (2021) showed that overall, only 33 rural health centers were fully efficient in Punjab.
Mbau et al., (2022), by reviewing 131 papers published between 2010 and 2021, concluded that the system of health of low- and middle-income countries was usually inefficient.

Recently, Sicari and Sutherland (2023) analyzed the efficiency of the health system in Ireland. For them although the health system in Ireland has evolved compared to others OECD countries, remain inefficient because the high rate of expending on health. This situation got even worse after the COVID-19 pandemic. The Ireland health system suffers from cost pressure.

A few studies have investigated health efficiency in Saudi Arabia (e.g., Albejaidi (2010); Almalki et al., (2011); Alatawi et al., (2020); Al Asmri et al., (2020); Bahurmoz (1998)). Since the 1990s Bahurmoz applied the operations research tools (DEA method) in health sector to evaluate their efficiency in KSA. It was the first study used DEA method in health sector in KSA. Their funding indicated that there was an efficiency of 96% of centers in Jeddah. Albejaidi (2010) used a simple statistical method to show that Saudi Arabia requires significant efforts to develop its health care system. The author found that between 2008 and 2010, the Saudi government invested 84.5 billion riyals in restructuring the health system. Almalki et al., (2011) provided an overview of health care development in Saudi Arabia and concluded that its health care system has suffered from many difficulties since 2011. Alatawi et al., (2020) utilized DEA to assess the technical efficiency of 91 public hospitals in Saudi Arabia, revealing that 75.8% of them were technically inefficient in 2017. Their results also showed that hospitals in the central region are more efficient than those in rural areas. Another DEA-based research is that of Benyoussef and Hemrit (2019), who evaluated the efficiency of insurance companies in Saudi Arabia. They asserted that insurance companies are inefficient and that Takaful insurance companies are relatively more efficient than their cooperative counterparts. Finally, Al Asmri et al., (2020) used a narrative method of previewing images from the Ministry of Health and the World Health Organization (WHO) to determine that additional improvements in the Saudi health sector are needed.

Overall, these studies verified that the Saudi health care system has undergone development, but there is a lack of empirical results to corroborate this. This deficiency stems from the use of narrative methods (i.e., those that do not derive empirical findings) (Almalki et al., (2011); Al Asmri et al., (2020)) or the fact that certain empirical results cover only the public health care system (Alatawi et al., (2020)). To fill this gap, we used an empirical method to explore the public and private health sectors in Saudi Arabia.

2. THE HEALTH SECTOR OF THE KSA

The health sector in Saudi Arabia is supervised by the Ministry of Health. However, as in many other countries, two sectors in Saudi Arabia provide health services: the government and the private sector. The government provides health care in all regions of Saudi Arabia through general and specialized hospitals and primary health care policies. Moreover, the Ministry of the Interior, the National Security Agency, and the Ministry of Defense provide health services for their employees.

The Saudi university also play an important role in health services, particularly by conducting medical research and training medical and paramedical personnel. The private sector plays a role in healthcare by setting up various hospitals, medical centers, and labs.

The private sector's share of Saudi health services has grown rapidly in recent years, reducing the burden on the Ministry of Health.

Health care has developed greatly in Saudi Arabia at the preventive and therapeutic levels. In 2018, the number of physicians per 10,000 population was 31.4. For nurses, this statistic is 55.2, and it is 37.2 for medical support staff.

This development is particularly noticeable in the evolution of the Ministry of Health's budget. Figure 1 shows the statistics on government funds allocated to the Ministry of Health from 2010 to 2018.

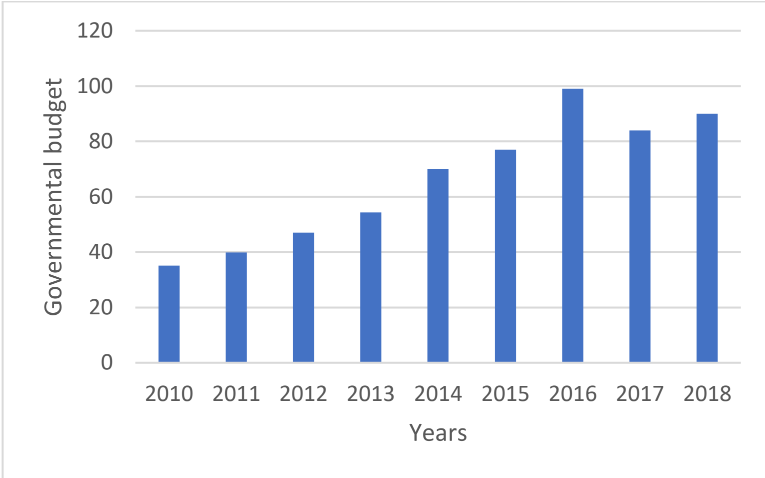

Figure 1. Total governmental budget for ministry of health (billion SR) between 2010-2018
Source of statistics: Statistical Yearbook of health ministry of KSA (2010-2018)

Figure 1 shows that the budget of the Ministry of Health increased in the 2010–2018 period. In 2016, the budget reached a maximum of about 100 billion Saudi riyals (SR). This increase in budget between the two years 2015 and 2016 can be explained by the Hajj accident at the end of 2015, which resulted in more than 2,000 deaths. In 2017, the Ministry of Health's budget decreased by almost 17 billion SR from its size in 2016. In 2018, the budget increased again.

In addition to household statistics, many other indicators confirm that health services in Saudi Arabia are still developing. Among these indicators are the numbers of doctors and nurses recruited each year. Figure 2 presents the evolution of the number of doctors in Saudi Arabia from 2010 to 2018.

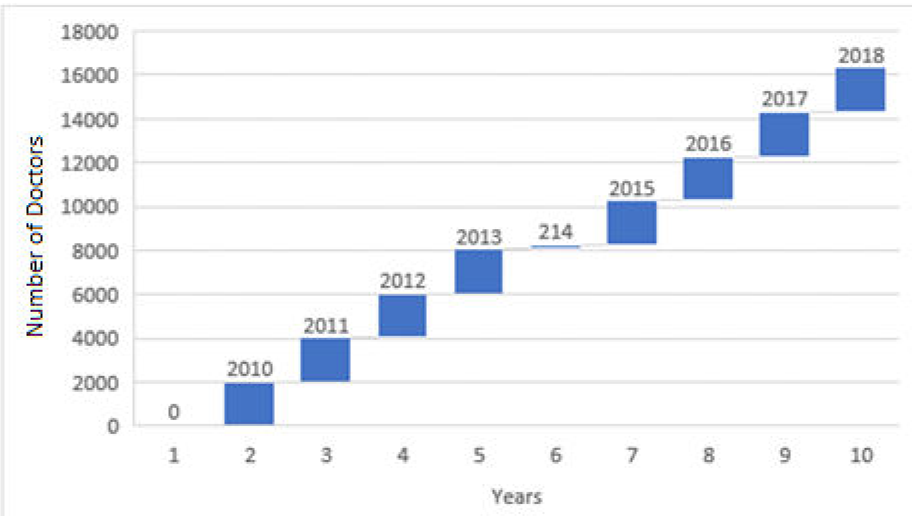

Figure 2. Number of doctors in KSA between 2010-2018
Source of statistics: Statistical Yearbook of health ministry of KSA (2010-2018)

The main conclusion we can draw from Figure 2 is that the number of physicians in Saudi Arabia has increased unceasingly over the 2010–2018 period. Except for 2014, the number of physicians has increased by about 2,000 each year. The number of doctors, which was 2,000 in 2010, reached 16,000 in 2018.

Similar to the increase in the number of doctors, there has been substantial growth in the number of nurses as well. From 75,978 in 2010, the number of nurses in Saudi Arabia increased to 10,5473 in 2018. Table 1 shows the evolution of the number of nurses.

Table 1. Evolution of Nurses number between 2010-2018 in KSA

Years	*Number of Nurses*
2010	75978
2011	77946
2012	82948
2013	83862
2014	91854
2015	98379
2016	101256
2017	103990
2018	105473

Source: Statistical Yearbook of health ministry of KSA (2010-2018)

Table 1 shows that the growth rate of the number of nurses between 2010 and 2018 is about 38.8%.

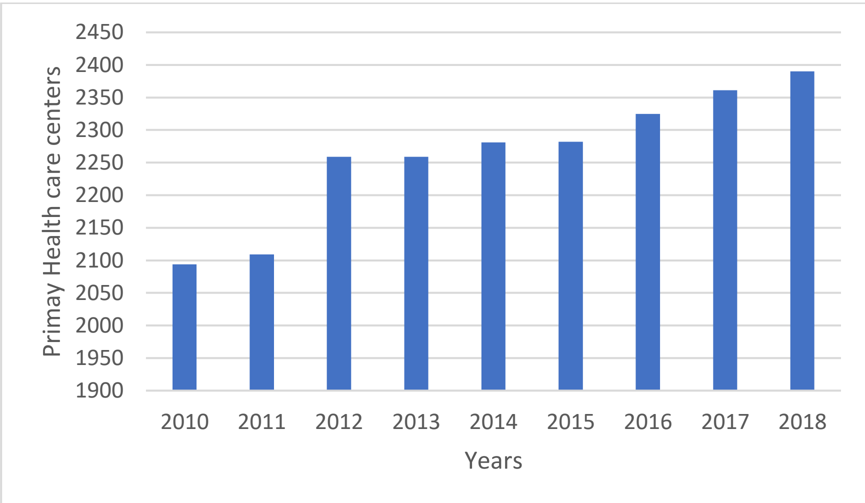

Figure 3. Primary Health care centers in ministry of health in KSA between 2010-2018
Source of statistics: Statistical Yearbook of health ministry of KSA (2010-2018)

In 2018, the centers with the most health centers in Saudi Arabia were Riyadh (447) and Aseer (254), and Qurayyat was at the bottom of the list, with only 19 health centers.

Table 2. Hospitals and beds in KSA between 2010-2018

	Government sector		*Private sector*	
Years	*Hospitals*	*Beds*	*Hospitals*	*Beds*
2010	249	34370	127	12817
2011	251	34450	130	13298
2012	259	35828	137	14165
2013	268	38970	136	14310
2014	270	40300	141	16054
2015	274	41297	146	16648
2016	274	41835	162	17428
2017	282	43080	163	17622
2018	284	43680	163	18883

Source: Statistical Yearbook of health ministry of KSA (2010-2018)

Table 2 shows that, like in the government sector, the number of hospitals and beds in the KSA's private sector continued growing from 2010 to 2018. Riyadh contained the largest number of hospitals (49) and beds (8,337) in 2018. The second position was occupied by Jazan, which had 21 hospitals and 2,225 beds in 2018. Medina had 19 hospitals and 2,768 beds. In Makkah, despite the Hajj and the Umrah, there were only 10 hospitals and 2,694 beds.

3. METHODOLOGY

In this work, we used a DEA technique, which is a nonparametric method based on linear programming. It was developed to compute the efficiency values of decision-making units (DMUs) formed from input–output combinations. DEA's additional advantage is that it allows for the consideration of multiple inputs and outputs in different valuation units. Multiple variations of the DEA technique have been created to assess effectiveness using Farrell's (1957) concept of technical efficiency. Charnes, Cooper, and Rhodes (1978) introduced the DEA method in the form of a linear programming model based on constant returns to scale (CRS). In 1984, a different model was created by Banker, Charnes, and Cooper (1984) which considered variable returns to scale (VRS).

Hence, the DEA assesses technical efficiency using CRS and evaluates pure technical efficiency using VRS. Scale efficiency (SE) is determined by dividing the score for technical efficiency by the score for pure technical efficiency; it measures whether a DMU operates under constant, increasing, or decreasing returns to scale. The efficiency score ranges from 0 to 1, with increased score indicating heightened efficiency.

Moreover, within the DEA technique, the output-oriented model is utilized to maximize outputs with a fixed amount of inputs, while the input-oriented model is used to minimize inputs with a set level of outputs.

Efficiency in a region is the total virtual output divided by the total virtual input, with weights determined for each unit during optimization. Suppose there are *n* DMUs, with each one utilizing *m* inputs to generate s outputs. The vector of inputs for DMU_j is represented as $X_j = (x_{1j}, \dots, x_{mj})^T$ and the outputs vector is $Y_j = (y_{1j}, \dots, y_{rj})^T$. The efficiency score for each hospital is calculated by formulating and solving model (1). The weights linked to the inputs are represented by the variables $\beta = (\beta_1, \dots, \beta_m)$, while the weights associated with the outputs are represented by $\omega = (\varepsilon_1, \dots, \varepsilon_s)$.
These weights are computed so that they yield the optimal efficiency score for every $region_{jo}$ being assessed.

The following is the input-oriented BCC model that ensures efficiency for the $region_{jo}$ under the VRS assumption:

$$\begin{aligned} &max\ \delta_{j0} = \frac{\varepsilon Y_{j0} - \varepsilon_0}{\beta X_{j0}} \\ &s.t \\ &\frac{\varepsilon Y_j - \varepsilon_0}{\beta X_j} \leq 1, \qquad j = 1, \dots n \\ &\beta \geq 0, \varepsilon \geq 0 \end{aligned} \tag{1}$$

It is important to observe that when the variable ε_o is removed from model (1), the CCR model is derived. The Charnes and Cooper transformation (referred to as C-C transformation in the future) (1978) can convert the fractional model (1) into a linear program. The transformation is made by selecting a scalar k ∈ R+ such as $k\beta X_{j0} = 1$ and then multiplying every component of model (1) with k>0 so that z =kβ, ω=kε, ω_o=kε_o. The is carried out by considering a scalar k ∈ R+ such as $k\beta X_{j0} = 1$ and multiplying all terms of model (1). The model (1) can be reformulated in linear form as:

$$\begin{aligned} &\max \omega Y_{j0} - \omega_0 \\ &s.t \\ &\omega Y_j - \omega_0 - zX_j \leq 0, \qquad j = 1, \dots n \end{aligned} \tag{2}$$

$$zX_{j0} = 1$$
$$z \geq 0, \omega \geq 0$$

After finding the best solution z^*, ω *, ω_0^* for model (2), the input-oriented BCC-efficiency δ_{j0}^* for the region$_{j0}$ being assessed can be determined from the objective function.

Banker et al., calculated the Returns to Scale (RTS) by utilizing the optimal value of the independent variable ω_0 in the multiplier model (2) (1984). The RTS at the point (x_0, y_0) on the efficient frontier are determined by three specific conditions:

1. Increasing Returns to Scale (IRS) occur at (x_0, y_0) if and only if ω *, $\omega_0^* < 0$ for every optimal solution. The rise in all input factors led to an increase in output levels.
2. Decreasing Returns to Scale (DRS) occur at (x_0, y_0) only when $\omega_0^* > 0$ holds true for every optimal solution, indicating that a uniform increase in all factors of production results in a decreased production output.
3. In any optimal solutions, CRS are successful at (x_0, y_0) only when $\omega_0^* = 0$, with equal increase in production factors leading to equal increase in production.

In our research, we utilized the output-oriented model with both CRS and VRS using two distinct databases. All outcomes were achieved utilizing Win4Deap2 (version 2.1.0.1).

4. RESULTS AND DISCUSSIONS

Choosing the input and output variables is important in evaluating performance as the efficiency measurements' results are heavily influenced by the variables in the estimation models. The literatures have concentrated on factors like capital (such as the quantity of beds) and labor (like health professionals) as inputs, with certain research also incorporating consumable resources like medications (Jacobs et al., 2006; Afzali et al., 2009). The primary types of results utilized in studies on efficiency in healthcare included healthcare tasks (such as outpatient visits, surgeries, inpatient services) and health effects (Jacobs et al., 2006; Varabyova & Müller, 2016; Kiadaliri et al., 2013).

In this research, we chose the results that are influenced by the chosen inputs, encompassing a broad array of health services and resources utilized by hospitals. We used two databases of 20 Saudi regions for the 2015–2019 period. The first database concerns primary health care centers and the second database relates to government hospitals.

Four inputs and three outputs were specifically selected for primary health care centers, as well as for government hospitals in KSA, based on data availability and previous studies' approval (Jacobs et al., 2006; Hollingworth, 2003; Hollingsworth, 2008).

The chosen input variables for primary health care centers were: 1) the number of primary health care centers; 2) the number of doctors; 3) the number of nursing staff and 4) the number of auxiliary medical. The output variables chosen are: 1) number of visits to clinics; 2) number of patients who benefited from radiography; 3) number of laboratory tests.
Regarding government hospitals, the chosen input variables were selected: 1) the number of doctors; 2) the number of nursing staff; 3) the number of auxiliary medical and 4) number of bad.
The output variables chosen in this database are: 1) number of patient visits to outpatient clinics; 2) number of patients who benefited from radiography; 3) number of laboratory tests and 4) number of inpatients.

Tables 3 and 4 summarize the study's descriptive statistics, including the number of observations, mean, standard deviation, minimum, and maximum of the input and output variables for the primary health care centers and the government hospitals, respectively.

Table 3. Summary statistics of inputs and outputs for primary health care centers

	Obs	*Mean*	*Std. Dev*	*Min*	*Max*
Inputs					
Input 1	20	113.66	90.00381	17.2	424.4
Input 2	20	483.17	352.4051	55.2	1536.6
Input 3	20	889.71	584.8059	155.8	2717
Input 4	20	523.21	420.7779	71.6	1830.6
Outputs					
Output 1	20	2740982	2020882	306511.4	7356130
Output 2	20	9762.62	9706.242	830.6	34106.4
Output 3	20	313255.6	284950.8	29735	1271846

Source: author's calculation

Table 4. Summary statistics of inputs and outputs for government hospitals

	Obs	*Mean*	*Std. Dev*	*Min*	*Max*
Inputs					
Input 1	20	1510.25	1327.401	264.4	6057.8
Input 2	20	5321.59	10036.27	664.2	47346.8
Input 3	20	2075.91	1779.966	400.8	8178.6
Input 4	20	2060.82	1652.775	300	8017
Outputs					
Output 1	20	1283783	1027704	210508.6	3790977
Output 2	20	327217.2	252302.3	50106.4	1106188
Output 3	20	7446227	6624518	1195818	2.77e
Output 4	20	76535.81	52290.31	14927.6	255160.6

Source: author's calculation

Tables 5 and 6 illustrate the correlation matrix between input and output variables for primary health care centers and government hospitals, respectively.

Table 5. Correlation matrix

	Input 1	*Input 2*	*Input 3*	*Input 4*	*Output 1*	*Output 2*	*Output 3*
Input 1	1						
Input 2	0.9153	1					
Input 3	0.9554	0.9556	1				
Input 4	0.8982	0.977	0.9393	1			
Output 1	0.7869	0.865	0.8296	0.8643	1		
Output 2	0.4077	0.6223	0.4772	0.6011	0.7501	1	
Output 3	0.389	0.5486	0.4312	0.5539	0.8398	0.8089	1

Source: author's calculation

According to Table 5, the Pearson correlation coefficients showed that there was no significant correlation between (Input1, Output2), (Input1, Output3), (Input2, Output2), (Input2, Output3), (Input3, Output2), (Input3, Output3), (Input4, Output2), or (Input4, Output3). Additionally, the coefficient of linear correlation was smaller than 0.75; there was a significant correlation between all other pairs of input and output, and the coefficient of linear correlation was more than 0.75 over the study period

Table 6. Correlation matrix

	Input 1	Input 2	Input 3	Input 4	Output 1	output2	output3	output4
Input 1	1							
Input 2	0.8932	1						
Input 3	0.9848	0.891	1					
Input 4	0.9827	0.9236	0.9842	1				
Output 1	0.8412	0.6776	0.8922	0.8615	1			
Output 2	0.9443	0.8193	0.9582	0.9449	0.9145	1		
Output 3	0.9555	0.8182	0.9594	0.9511	0.9284	0.9769	1	
Output 4	0.9358	0.8774	0.9529	0.9649	0.8899	0.9652	0.949	1

Source: author's calculation

Table 6 also shows the correlation between inputs and outputs for government hospitals. We found a strong correlation between all pairs of inputs and outputs; the coefficient of linear correlation was more than 0.80.

Table 7. Mann-Whitney test for crste and vrste efficiency scores

	Constant returns to Scale Technical Efficiency	*Variable Returns to Scale Technical Efficiency*
Mann-Whitney U	*101.5*	*122.5*
Wilcoxon W	*311.5*	*332.5*
Z	*-2.693*	*-2.167*
Asymp. Sig. (2-tailed)	*0.007*	*0.03*
Exact Sig. [2(1-tailed Sig.)]*	*0.007[b]*	*0.035[b]*

Source: author's calculation

According to Table 7, the value of the Mann-Whitney test is equal to 101.5 for the CRST efficiency scores and 122.5 for the VRST efficiency scores. Additionally, the z value equals -2.693 and -2.167 for the crste and vrste efficiency scores, respectively. This is a non-significant value at the 0.05 level, because the significance level is equal to 0.007 and 0.03 for the crste and vrste efficiency scores, respectively which are lower than 0.05. Which means that there are statistically significant differences between primary health care centers and government hospitals.

Table 8 displays the findings from the initial stage examination of DEA models, showcasing summary statistics for average technical efficiency (CRS and VRS), scale efficiency (SE) scores, and return to scale for primary health care centers and government hospitals. The efficiency scores in (Appendix 1 and 2).

Table 8. DEA results for primary health care centers and government hospitals

	primary health care centers			*government hospitals*		
	CRS	*VRS*	*SE*	*CRS*	*VRS*	*SE*
All regions (n=20)						
Average score	0.73	0.8	0.92	0.87	0.92	0.95
Standard deviation	0.18	0.18	0.13	0.13	0.1	0.08
Maximum efficiency score	1	1	1	1	1	1
Minimum efficiency score	0.5	0.51	0.52	0.65	0.71	0.68
Number (and %) of efficient DMUs	4 (20%)	6 (30%)	4 (20%)	7 (35%)	9 (45%)	7 (35%)
Returns to scale						
Efficient DMUs exhibiting IRS	12	-	-	2	-	-
Efficient DMUs exhibiting CRS	4	6	4	7	10	7

Efficient DMUs exhibiting DRS	4	-	-	11	-	-

CRS, Constant Returns to Scale; VRS, Variable Returns to Scale; SE, Scale Efficiency; DRS, Decreasing Returns to Scale; IRS, Increasing Returns to Scale;
Source: author's calculation

According to Table 8, the primary health care centers had an average technical efficiency (CRS score) of 0.73, with a standard deviation (SD) of 0.18. This suggests that, on average, the centers could reduce their input usage by 27% without affecting their outputs. On average, the VRS technical efficiency score is 0.80 with a standard deviation of 0.18. Figure 4 displays the allocation of primary health care centers based on their technical, purely technical, and scale efficiency scores.

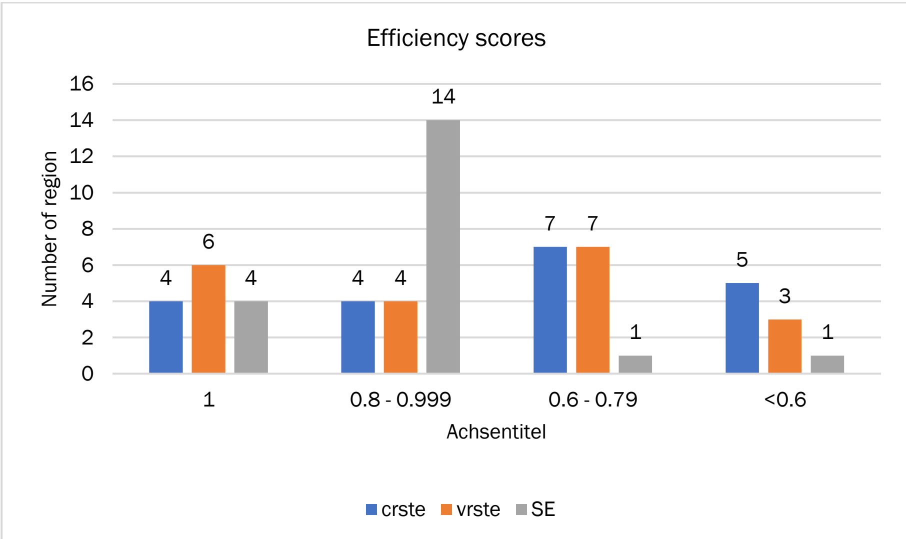

Figure 4. Distribution of primary health care centers across technical efficiency scores of technical (CRS), pure technical (VRS) and scale efficiencies
Source: own

The minimum reported efficiency score is 0.65; nevertheless, 4 regions out of 20 (20%) are efficient in both CRS technical efficiency and scale, showing they use their resources efficiently (refer to Appendix 1). Out of the regions that were not efficient, 11 regions (55%) had technical efficiency scores of 0.60 or higher (Figure 6), while 5 regions (25%) had scores below 0.60. While 6 regions (30%) achieved a high score for pure efficiency on the VRS, only 4 regions (27%) were efficient on the overall scale.

Additionally, Table 8 shows that government hospitals had an average technical efficiency (CRS score) of 0.87 and a standard deviation (SD) of 0.13. This suggests that, on average, government hospitals could reduce the use of all inputs by 13% without affecting their outputs. The average VRS technical efficiency score is 0.92, with a standard deviation of 0.10. Figure 5 displays the distribution of government hospitals in terms of their technical, pure technical, and scale efficiency scores.

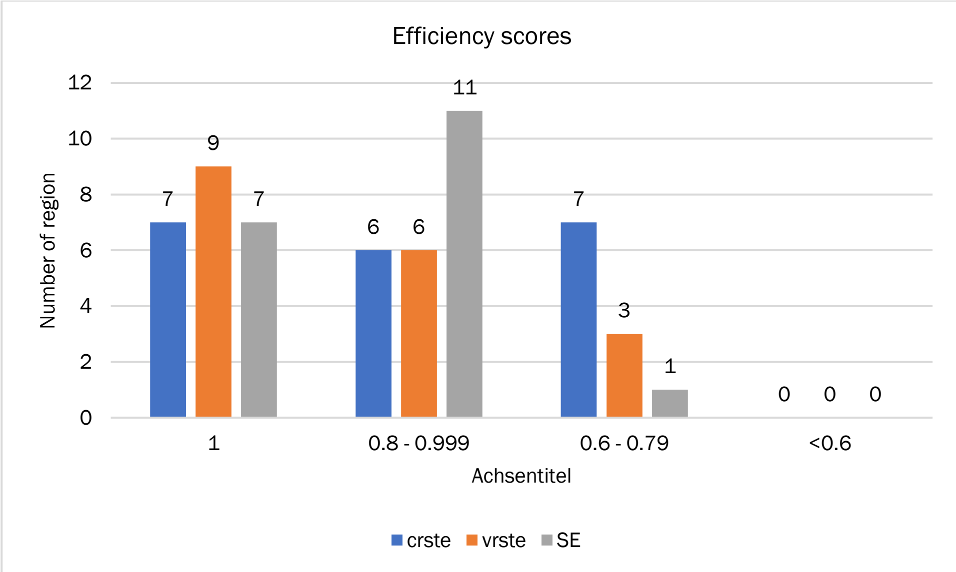

Figure 5. Distribution of government hospitals across technical efficiency scores of technical (CRS), pure technical (VRS) and scale efficiencies
Source: own

The minimum efficiency score reported is 0.71, but 7 out of 20 regions (35%) are efficient in CRS technical efficiency and scale, suggesting they are using their inputs effectively (refer to Appendix 2). Out of the ineffective areas, 13 regions (equivalent to 65%) showed technical efficiency scores of 0.60 or higher (as shown in Figure 7), with no region reporting efficiency scores (CRS, VRS, and SE) lower than 0.60.

Regarding returns to scale, we have discovered 4(20%), 7(35%) regions operated under CRS for primary health care centers and government regions, respectively. While 12(60%), 2(10%) regions operated under IRS for primary health care centers and government regions, respectively, and 4(20%), 11(55%) regions under DRS for primary health care centers and government regions, respectively. Nevertheless, the areas that used IRS or DRS had to modify their capabilities to function at the most efficient scale size to attain technical efficiency.

Figures 6 and 7 show the efficiency scores of CRS and VRS for primary health centers and government hospitals, respectively. The two graphs show both efficient and inefficient regions.

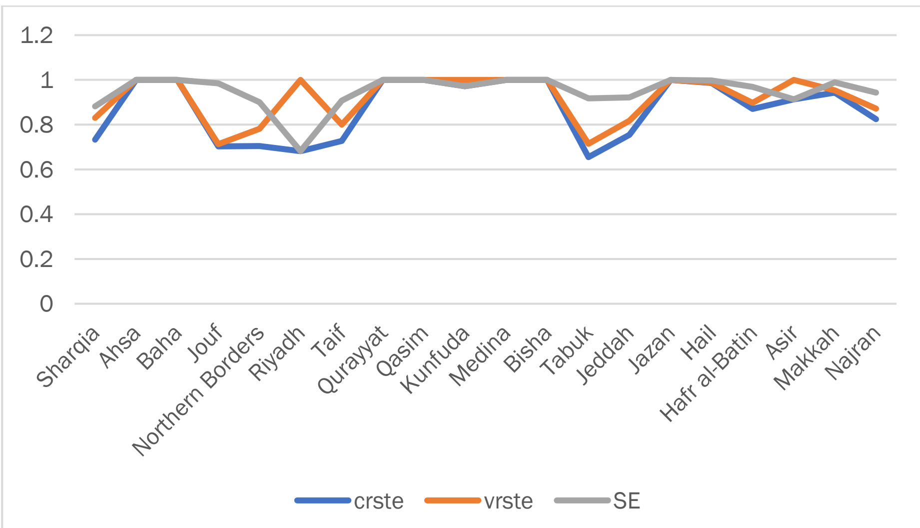

Figure 6. Efficiency crste vs vrste scores for primary health care centers

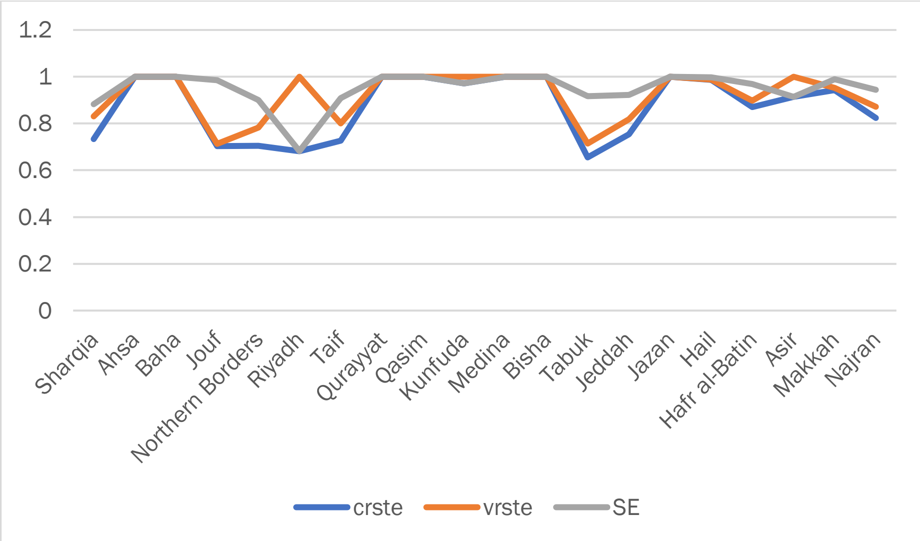

Figure 7. Efficiency crste vs vrste scores for government hospitals
Source: own

Figures 6 and 7 illustrate the distribution of CRS, VRS, and scale (SE) scores for both primary healthcare centers and government hospitals.

Tables 9 and 10 show the percentage of increase in the quantity of inputs or outputs needed by primary healthcare centers and government hospitals to address inefficiencies

Table 9. Slacks evaluation for inefficient regions of primary health care centers

Inputs slacks	*Mean*	*Std. Dev*	*percentage of change*
Input 1	18.69	25.72	-16.43
Input 2	36.82	82.02	-7.62
Input 3	209.31	202.56	-23.52
Input 4	44.11	103.18	-8.43
Outputs slacks			
Output 2	3855.11	6202.88	39.49
Output 3	159464	202599.9	50.90

Source: author's calculation

In terms of the inputs, data presented in Table 9 indicates that an abundance of Input 3 had the greatest impact. Reason for inefficiencies at primary healthcare facilities. On average, the possible and attainable decrease in Input 3 was 23.52% of the current Input 3, as compared to the average detailed in Table 3. The most significant amount of slack was seen in Input 1, with an excess usage of 16.43%. The excess amounts of Input 4 and Input 2 played a significant role in causing inefficiency and need to be decreased by around 8.43% and 7.62%, respectively.

Moreover, the average number of Output 2 and Output 3 could be raised by 39.49% and 50.90% respectively, in order to achieve the desired level of effectiveness

Table 10. Slacks evaluation for inefficient regions of government hospitals

Inputs slacks	**Mean**	**Std. Dev**	**percentage of change**
Input 1	62343.71	145203.8	-5.26
Input 2	12568.51	32109.75	-1.51

Input 3	586021	870598.6	-3.15
Input 4	2404.76	6214.91	-2.73
Outputs slacks			
Output 1	79.43	169.65	4.86
Output 2	80.36	150.85	3.84
Output 3	65.49	160.29	7.87
Output 4	56.29	102.30	3.14

Source: author's calculation

Similarly, Table 10 shows that inefficient government hospital regions must decrease, on average, their Input1, Input2, Input3, and Input4 by 5.26%, 1.51%, 3.15%, and 2.73%, and increase, on average, their Output1, Output2, Output3, and Output4 by 4.86%, 3.84%, 7.87%, and 3.14% of the current values (in comparison with the average listed in Table 4) to become efficient regions

Table 11. Projection summary for the Jouf region

Variable value	*Original* movement	*Radial* movement	*Slack* value	*Projected*
Output 1	449015	180487.604	40946.012	670448.62
Output 2	145109.8	58328.831	0	203438.63
Output 3	2660516	1069430.1	330336.15	4060282.3
Output 4	40802.6	16401.153	0	57203.753
Input 1	689.2	0	0	689.2
Input 2	2330.2	0	-443.756	1886.444
Input 3	870	0	0	870
Input 4	1216	0	-109.917	1106.083

Source: author's calculation

Table 11 is an illustrative example of the slack value of the Jouf region's for government hospitals. This region is considered inefficient (CRS = 0.703, VRS = 0.713; see Appendix 1). To be an efficient region, it should reduce the number of nursing staff (Input2) and the number of bad (Input4) by 443.756 and 109.917, respectively, and increase the number of patient visits to outpatient clinics (Output1) and the number of laboratory tests (Output3) by 40946.012 and 330336.15, respectively. In the same way, we can analyze all other inefficient regions of primary healthcare centers and government hospitals.

CONCLUSION

This paper has presented real-world data on how well primary healthcare centers in Saudi Arabia compare in efficiency to the government. We discovered reliable and strong outcomes, indicating similar effects of different variables on efficiency measurements when using alternate databases. The study in this paper focused on measuring efficiency levels and analyzing factors that affect efficiency. Our research involved examining two databases - primary healthcare centers and government hospitals in 20 regions of Saudi Arabia from 2015 to 2019, utilizing CRS and VRS models, indicating a comprehensive national scope.

This paper is unique in that it utilizes national datasets from Saudi Arabia to cover various factors that affect the efficiency of primary healthcare centers and government hospitals. The results showed that the average CRS and VRS scores of primary health care centers over five years were 0.728 and 0.799, respectively. For government hospitals, these scores were 0.873 and 0.918, respectively. In addition, the results showed that the number of efficient regions (9) for government hospitals was greater than the number of efficient regions (6) for primary healthcare centers. This indicates that primary healthcare centers are more efficient than government hospitals. The results of this study will help to understand the reasons for inefficiencies in primary healthcare centers and government hospitals.

The inefficient regions of primary healthcare centers should decrease, on average, the number of primary health care centers by 16.43%, the number of doctors by 7.62%, the number of nursing staff by 23.52%, and the number of auxiliary medical by 8.43%. To be an efficient region, the same centers should increase, on average, the number of patients who benefited from radiography by 39.49% and the number of laboratory tests by 50.90%.

The inefficient regions of government hospitals must decrease, on average, the number of doctors by 5.26%, the number of nursing staff by 1.51%, the number of auxiliary medical by 3.15%, and the number of bad by 2.73%. On average, to be an efficient region, they should increase the number of patient visits to outpatient clinics by 4.86%, the number of patients who benefited from radiography by 3.84%, the number of laboratory tests by 7.87%, and the number of inpatients by 3.14%.

Additional research can be conducted to gain insight into the national-level production process and its efficiency by broadening the range of inputs, outputs, institutional and environmental factors, as well as population characteristics and healthcare service utilization.

Furthermore, the scope of efficiency studies could be broadened to include different topics (such as various types of evaluation methods), approaches (such as SFA), and the populations being studied. In relation to the sample, future studies could focus on primary healthcare centers and government hospitals, as well as other providers such as the private sector or different departments within hospitals.

The results of this study emphasized the significance of evaluating efficiency in primary healthcare centers and government hospitals, as well as the healthcare system overall. This is crucial for creating and improving health policies to maximize healthcare services with the available resources.
Furthermore, future research focusing on the effectiveness of primary healthcare centers and government hospitals will contribute to enhancing the understanding of how public funds can be optimized to achieve Universal Health Coverage in Saudi Arabia and other similar countries.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

ACKNOWLEDGEMENT

The authors extend their appreciation to the Deanship of Scientific Research, Imam Mohammad Ibn Saud Islamic University (IMSIU), Saudi Arabia, for funding this research work through Grant No. (221411005)

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APPENDIX RELATED TO DEA ANALYSIS

Appendix A: Technical efficiency scores and returns to the scale of primary health care centers.

Regions	*CRS technical efficiency*	*VRS technical efficiency*	*Scale efficiency*	*Return to Scale RTS*	*Peers (Frequencies)*
Sharqia	1	1	1	CRS	14
Ahsa	0.873	0.953	0.916	IRS	0
Baha	0.663	0.702	0.944	IRS	0
Jouf	0.614	0.681	0.902	IRS	0
Northern Borders	0.864	0.934	0.925	IRS	0
Riyadh	0.522	1	0.522	DRS	0
Taif	0.534	0.545	0.979	DRS	0
Qurayyat	0.605	1	0.605	IRS	11
Qasim	0.504	0.505	0.999	IRS	0
Kunfuda	1	1	1	CRS	6
Medina	0.855	0.858	0.996	IRS	0
Bisha	1	1	1	CRS	2
Tabuk	0.682	0.729	0.936	IRS	0
Jeddah	0.585	0.609	0.961	IRS	0
Jazan	0.84	0.846	0.993	IRS	0
Hail	0.635	0.646	0.984	DRS	0
Hafr al-Batin	0.651	0.744	0.875	IRS	0
Asir	0.522	0.572	0.911	DRS	0
Makkah	1	1	1	CRS	3
Najran	0.609	0.651	0.936	IRS	0

Source: author's calculation

Appendix B: Technical efficiency scores and returns to the scale of government hospitals.

Regions	*CRS technical efficiency*	*VRS technical efficiency*	*Scale efficiency*	*Return to Scale RTS*	*Peers (Frequencies)*
Sharqia	0.733	0.831	0.882	DRS	0
Ahsa	1	1	1	CRS	7
Baha	1	1	1	CRS	1
Jouf	0.703	0.713	0.985	DRS	0
Northern Borders	0.704	0.782	0.9	DRS	0
Riyadh	0.682	1	0.682	DRS	4
Taif	0.727	0.8	0.908	DRS	0
Qurayyat	1	1	1	CRS	6
Qasim	1	1	1	CRS	7
Kunfuda	0.972	1	0.972	IRS	0
Medina	1	1	1	CRS	5
Bisha	1	1	1	CRS	0
Tabuk	0.655	0.714	0.917	DRS	0
Jeddah	0.754	0.818	0.922	DRS	0
Jazan	1	1	1	CRS	0
Hail	0.986	0.988	0.998	IRS	0
Hafr al-Batin	0.87	0.898	0.969	DRS	0
Asir	0.914	1	0.914	DRS	5
Makkah	0.943	0.953	0.989	DRS	0
Najran	0.824	0.872	0.944	DRS	0

Source: author’s calculation